sphere, or rather to a height where the density of the air is very small, and that it must be started with such a velocity that in spite of the air resistance in the first part of its course, its remaining speed, after having reached the upper air, shall be sufficient for its further progress.

At the surface of the earth and with ordinary projectile velocities (2000 to 3000 ft. per sec.) the resistance of the air is large compared with the weight of the shot, even for a 12-in. projectile, though, of course, this ratio decreases in the proportion of the area to the volume.

In the absence of air resistance, elementary dynamics show that if a projectile (or particle) is started upwards with an inclination of 45° the ranges would be as follows:—

Initial velocity		Range
1000 ft./sec.	... ...	11·6 miles
2000 ,,	... ...	47 ,,
3000 ,,	... ...	106 ,,
4000 ,,	... ...	188 ,,
5000 ,,	... ...	296 ,,

It is evident, therefore, that, if a gun is to carry seventy or eighty miles, the shot must attain a height where the air resistance is very small, with a remaining velocity of between 2000 and 3000 ft. per sec.

If the temperature of the air at all heights were constant, the air itself would extend to an infinite height, the pressure and density being connected to well-known laws. If, on the other hand, the temperature decreases adiabatically with the height (as is found to be the case, at any rate, up to 40,000 ft. or thereabouts), there is a finite limit of about seventeen miles above which no oxygen or nitrogen could exist. Above this height a projectile would experience no resistance, but even a few miles lower the resistance would be small compared with its weight.

By using graphic methods there is no difficulty in deducing the retardation which the shot undergoes in the earlier part of its flight, though these methods cannot be shown in full in this short article.

I have not computed the requisite initial velocity for a 9-in. shot (such as is said to have been used in the German gun), but it must be of the order of 5000 ft, per sec.

Data for air resistance up to this speed will be found in a paper read by me before the Royal Society on May 28, 1908.

To attain this speed a long bore would probably be more suitable than an extra-strong explosive; at least, this is what I found to be the case in my own experiments.

In the statement given above as to ranges *in vacuo* it has been assumed that the trajectory was parabolic. In reality, of course, it is part of a very long ellipse, the projectile, in fact, behaving as a satellite with an eccentric orbit of which the elements can be readily calculated.

A. Mallock.

CLOUD FORMATIONS AS OBSERVED FROM AEROPLANES.

THE recent development of aviation has provided a means of observing clouds which is much superior to any hitherto known. A modern aeroplane can reach the clouds in a very short time, and in many cases get above them. Observations of temperature can easily be obtained, and probably humidity observations would present no great difficulties. The "bumps" experienced also give some information as to the nature of the disturbance causing the formation of the clouds.

It is well known that the two most important processes which cause clouds to form are (1) the mixture of layers of air of high humidity and different potential temperature,[1] (2) adiabatic expansion due to upward movement.

The first process is the cause of most horizontal cloud-sheets, and the latter of the most typical cumulus clouds and also of rain-clouds. Many clouds of cumulus and strato-cumulus character are due to both processes combined.

It has not hitherto been clearly understood precisely how cloud-sheets a few thousand feet above the surface are formed. Observations from aeroplanes show that under these cloud-sheets there is always some vertical disturbance and a lapse-rate of temperature (*i.e.* a rate of decrease of temperature with height) which is little below the adiabatic rate for dry air, while above the clouds the air is undisturbed, and there is a marked rise of temperature for a few hundred or a thousand feet above the clouds. The disturbance within and below the clouds is not violent in the case of a horizontal cloud-sheet, and is of the same nature as the eddy motion discussed by Major Taylor[2] with reference to the fogs off the Newfoundland Banks. The disturbance is transmitted upwards from the earth's surface, and consists of a fairly regular distribution of eddies, which do not last long, the disturbed air soon mixing with the surrounding air. The effect of heating or cooling the air at the surface has been discussed by Major Taylor, but the type of cloud-sheet we are now considering is caused rather by the movement of a body of air over a wide stretch of sea where there is not much change of temperature. In the course of time the air up to the height of a few thousand feet is thoroughly mixed, with the result that the lapse-rate of temperature becomes adiabatic and the relative humidity increases with height; in many cases a cloud-sheet forms at the top of the disturbed layer of a thickness usually less than 1500 ft., often less than 500 ft. As the normal lapse-rate for the atmosphere generally is less than the adiabatic, there is an increase of temperature on passing from the disturbed to the undisturbed layer, which renders slow the further upward penetration of the eddy motion.

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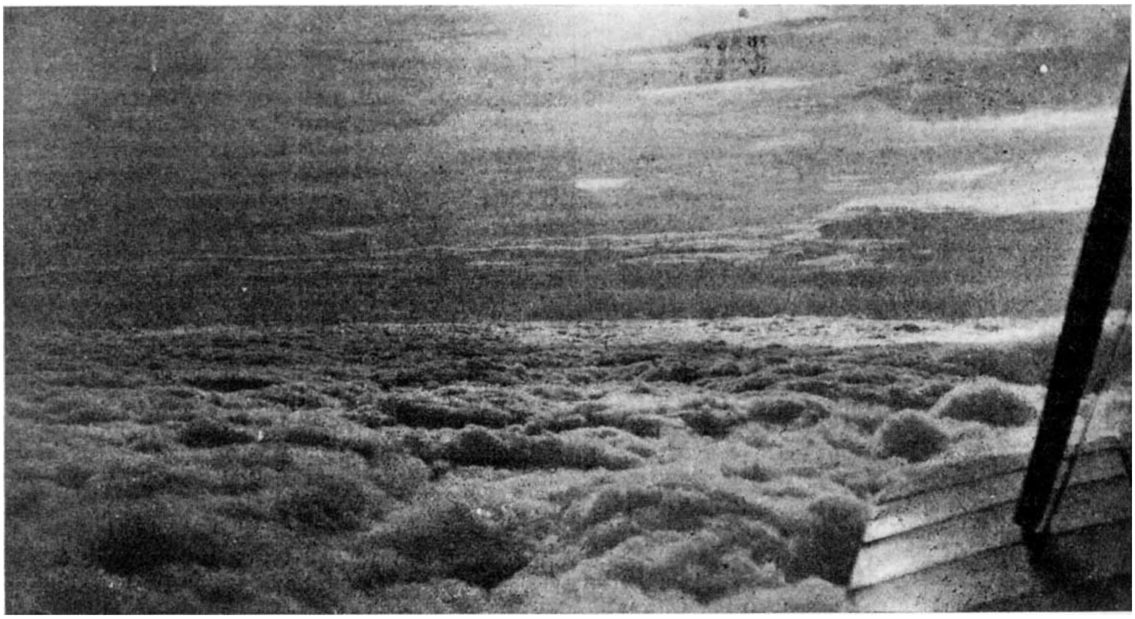
[1] Potential temperature is the temperature which a specimen of air would acquire if it were brought down, under adiabatic conditions, from the position it occupied to the earth's surface.

[2] See (1) "Report on the Work carried out by the S.S. *Scotia*, 1913," pp. 48–68 (London, 1914), and, also by Major Taylor, (2) "Eddy Motion in the Atmosphere" (*Phil. Trans*, A Series, vol. ccxv. (1915), pp. 1–26) and (3) "The Formation of Fog and Mist" (*Quarterly Journal Roy. Met. Soc.* vol. xliii., No. 183, July, 1917).

Any meteorological condition which causes a body of air to cover a wide stretch of sea without any irregular disturbance favours the development of cloud-sheets of this type. Fig. 1[3] shows an example of a cloud-sheet which occurred at Brooklands on September 26, 1917, with a well-marked south-westerly current. The clouds extended from 3000 ft. to 4000 ft., and there was a temperature recovery of 6° F. in 200 ft. above them; there was some irregular disturbance near the ground, but not sufficient to disturb the cloud-sheet, where the eddies were evenly distributed. This type of cloud-sheet is most common in quiet winter weather, and the eddies are then not so well marked as in Fig. 1, but are, nevertheless, easily seen, and cause the clouds to be called "strato-cumulus." In anticyclones the air is very warm above the clouds, and in winter the temperature recovery may amount to 15° F. in 1000 ft., as on December 22, 1917, and January 5, 1918, in northern France. Cloud-sheets at these two dates were almost certainly formed originally over the sea; the first was at about 5000 ft., moving from N.N.E., the second at about 4000 ft., moving from W.S.W. For fully 2000 ft. below the cloud-sheets there was much turbulence and an adiabatic lapse-rate, while within 1500 ft. of the ground there was no turbulence noticeable to aeroplanes, and the lapse-rate was zero. Such advances of turbulent cloud-sheets from the sea over the top of comparatively tranquil air near the ground are common in winter in Britain and northern France. Their effect in preventing nocturnal radiation is of great importance.



C. K. M. D.

Fig. 1.—Strato-cumulus at 4000 ft. Rise of temperature 6° F. in 200 ft. above clouds. High clouds of approaching "rain-line" above. Taken, from 6000 ft., Brooklands, 4.30 p.m., September 26, 1917.

The clouds of the cumulus class are caused by turbulence on a much larger scale than that which occurs in the horizontal cloud-sheets. They are formed with strong winds or when the air is being heated at the surface, and are commonest over land and on summer days. The winds crossing the irregular surface of the land, or local differences of temperature, give rise to small variations of pressure, which cause irregular vertical currents and corresponding variations in the horizontal wind velocity. The vertical currents do not usually last long, and soon mix with the surrounding air, but the turbulence extends upwards, and thoroughly mixes the air up to the height of a few thousand feet. The turbulence in these conditions is more violent and less regular than that which causes horizontal cloud-sheets. The clouds are due partly to mechanical mixing of layers of different temperature, partly to the adiabatic expansion of ascending air. The form may be cumulus, fracto-cumulus, or strato-cumulus, and the amount depends mainly on the humidity of the layers mixed up. When the turbulence is due mainly to the wind passing over obstacles on the ground, the temperature of the top of the turbulent region is reduced, and a temperature inversion is often formed above the clouds. The irregular disturbances cause the upper surface of the clouds to be uneven, as in Fig. 2, where the variations of the level of the tops of the clouds amounted to 1000 ft. The highest portions of these clouds reached 8000 ft., and the temperature recovery above these portions amounted to 6° F. There was already a thin, broken, horizontal cloud-sheet at 7000 ft., with a slight rise of temperature above it, before it was disturbed by the cumuli rising from below.

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[3] [We are indebted to the Scottish Meteorological Society for permission to reproduce the three photographs illustrating Capt. Douglas's paper. They are selected from a beautiful series of thirteen, all taken by Capt. Douglas, which accompany a paper by him on "The Lapse-line and its Relation to Cloud Formation" in the last issue of the Society's Journal, Third Series, vol. xvii., No. 34).—Ed. Nature.]

On days when the disturbance is due mainly to heating at the surface, and no cloud-sheet or damp layer exists at the height of a few thousand feet, the clouds usually retain the form of cumuli, which are, as a rule, contained within a definite layer the level of which rises during the day. When the clouds have risen to 2000 ft. or more above the surface, the lapse-rate near the ground is adiabatic, but this is not usually the case at the cloud level, with the result that the clouds at the top of the ascending currents are usually colder than the surrounding air, being forced up by small irregularities of pressure. Once the lapse-rate near the ground is adiabatic, large bodies of air may be forced up in this way, forming banks of cumulus clouds. If these enter a layer the lapse-rate of which is above the adiabatic for saturated air, these large cumuli may become warmer than the surrounding air and continue to ascend, and perhaps finally cause showers or thunderstorms. The tops of thunderstorms are seldom below 15,000 ft., and the top of heavy showers usually above 10,000 ft., though if the lower air is very damp, showers may fall from a much lower level. Fig. 3 shows tops of cumuli at about 9500 ft. joined to a shower on the right, and also patches of stratus

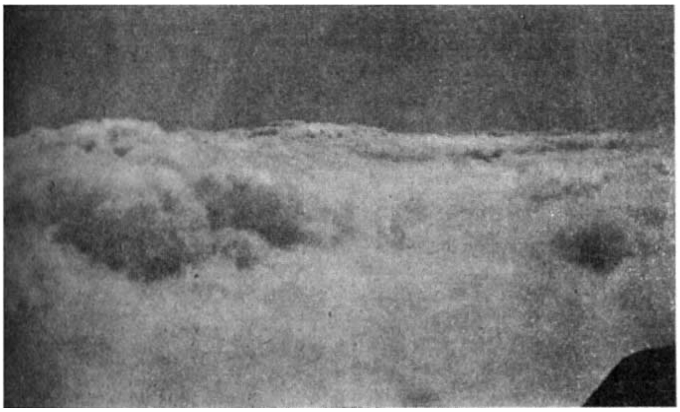
C. K. M. D.

Fig. 2.—Strato-cumulus clouds. Tops 7000 ft. to 8000 ft. Rise of temperature 6° F. in 100 ft. above highest parts. Taken, from about 8000 ft., Brooklands, 11 a.m., August 16, 1917.

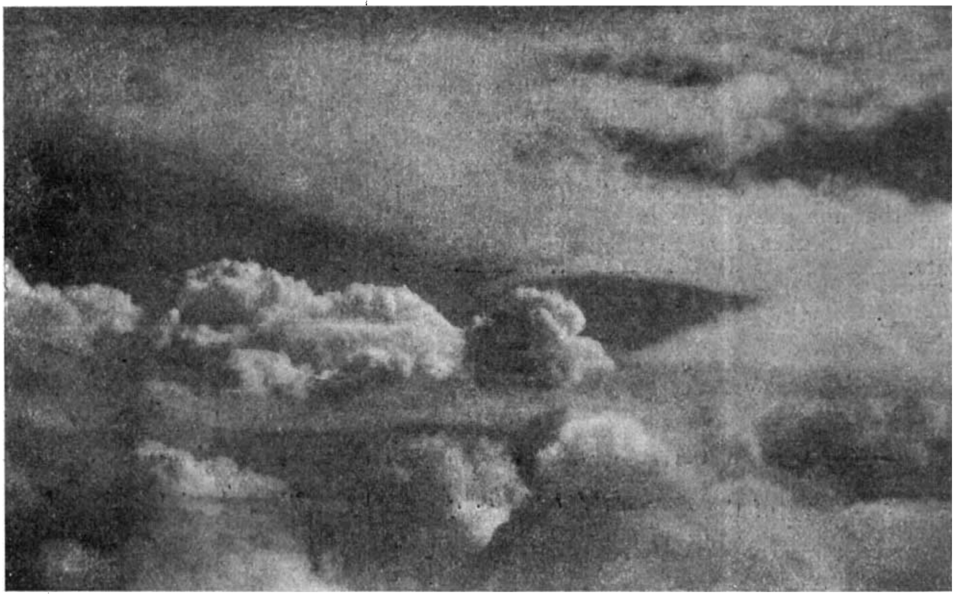
C. K. M. D.

Fig. 3.—Cumuli, with stratus patches and thin stratus above. Tops of cumuli, 9500 ft.; stratus patches, 8000 ft.; thin stratus above, 10,000 ft. Clouds joined to shower on right. Taken, from about 8500 ft., Brooklands, 2 p.m., August 20, 1917.

We have hitherto only been considering clouds which are due to disturbances originating at the surface. The majority of the upper clouds are entirely independent of superficial disturbances. The same is true of many types of rain-cloud, which are due to upward movement on a large scale; even thunderstorms sometimes develop with their bases at the height of fully 8000 ft., and are independent of disturbances originating at the surface. In many cases rainfall develops over a wide area from high cloud-sheets, which gradually extend downwards as the upward movement becomes more pronounced. The rain area may advance over a wide tract of country, preceded by a high cloud-sheet. The rain-clouds consist of thin mist extending to a great height and in winter, and at any season above 10,000 ft., they may consist only of thin snow. In France the snow-storm of January 9, 1918, developed from a cloud-sheet of this type, which originally came over high up, and later at lower heights, the snow being finally continuous from the ground to a great height. Rain-clouds of this type may be uniform over wide areas, and there may also be turbulent cloud-sheets near the surface, sometimes joined to the rain-clouds. Sometimes also the lower clouds gather into large cloud-heaps, which cause heavy showers in the middle of the other rain-clouds. The high rain-clouds may themselves be broken into showers by local vertical movements, so that rainfall production is usually a complicated process.

The writer has not had enough hign flying to be able to make many observations of the upper clouds, but they certainly present an interesting field of investigation well within the possibilities of aeroplanes.

C. K. M. DOUGLAS.

PHOTOGRAPHIC DETERMINATIONS OF STELLAR PARALLAX.[1]

THE determination of stellar parallaxes by photography has shown a striking improvement in recent years, and the results obtained with the Yerkes refractor are of the highest order of excellence. Two of the precautions observed in this and similar series of measures are the taking of all the plates at small hour-angles, so as to minimise the effect of unequal atmospheric dispersion in the stars, and the reduction of the magnitude of the parallax star to equality with the comparison stars. This latter precaution is necessary, since any inequality in the driving will have a different effect on the images of objects that differ much in brightness. The usual way of effecting this is by rotating a screen in the form of a sector of a circle in front of the brighter image. By altering the angle of the sector, any desired diminution of light may be obtained.

This method was used for most of the parallaxes in the volume under notice, which, however, mentions an alternative plan, due to Prof. Kapteyn, that has been successfully tried at Yerkes. It consists in taking an out-of-focus photograph of the required region, which on development exhibits the stars as discs of equal size but unequal density. This negative is then used as a screen for the parallax plate. Since the density of each disc is proportional to the photographic brightness of the star that formed it, it is clear that the use of the screen will give nearly equal magnitudes for the stars on the parallax plate.

The parallax work at Yerkes Observatory was begun in 1903 by Dr. Schlesinger, who was appointed director of Allegheny Observatory in 1905; it was continued by Messrs. Slocum, Mitchell, Lee, Joy, and van Biesbroeck (of the Uccle Observatory, Belgium). Up to the end of 1915 131 parallaxes had been determined. The present volume contains the details of the last eighty-five, and a summary of the earlier results, which have already been published. The parallax stars are mainly bright ones, but nearly one-third of them are faint stars with large proper motions.

The parallax of Algol is given as 0·02″; that of 61 Cygni, 0·27″; of 70 Ophiuchi, 0·21″; of ε Lyræ (the double-double), 0·00″ (all four components being measured); O.A. (N.) 17,415–6, 0·22″. There are six of the eighty-five parallaxes between 0·1″ and 0·2″, three above 0·2″, and seventy-six less than 0·1″. Four of the stars in the trapezium of the Orion nebula were measured, as there is little doubt that they are actually involved in the nebula. The results are negative for all four (−0·014″, −0·026″, −0·021″, −0·023″), presumably indicating that the trapezium and nebula are more remote than the comparison stars. The possibility is recognised that the latter may themselves be involved in the nebulosity, and a further investigation is suggested, using larger plates that would include stars more distant from the trapezium.

The probable errors of these parallaxes are all in the neighbourhood of 0·01″. The error that is reasonably possible is, of course, two or three times as great. A good illustration of this fact is afforded by the parallaxes found for the pair of stars O.A. (S.) 14,318–20, R.A. 15h. 5m., S. decl. 16°. They are 5′ apart, magnitudes 9·6 and 9·2, spectral types G_5 and G_4, P.M.s 3·693″ in 195·7° and 3·675″ in 195·6°, radial velocities +307 km. and +295 km. These striking facts leave no reasonable doubt that the two stars are physically connected, and have sensibly equal parallaxes. The present volume gives for the parallaxes +0·025″ ± 0·008″ and +0·061″ ± 0·012″ respectively. As Prof. H. N. Russell had previously obtained the values +0·014″ ± 0·023″, +0·045″ ± 0·022″, some astronomers have adopted the view that one star is really some three times as distant as the other. But the close agreement of their abnormally large proper motions renders such a conclusion wildly improbable. In fact, the weighted mean parallax is 0·040″ from the Yerkes plates, and 0·030″ from those of Prof. Russell, a quite satisfactory accordance.

An appendix to the volume gives a detailed description of the measuring machine in use for these photographs. It was made by William Gaertner and Co., Chicago. The screw is 18 mm. in diameter, with 249 threads 1 mm. apart. The nut is 50 mm. long, and the graduated head 18 cm. in diameter, having 1000 graduations. The errors of the screw are extremely small.

A. C. D. CROMMELIN.

THE SIKKIM HIMALAYA.

NO section of the Himalaya is more fully known than Sikkim; Kashmir even has not been more assiduously investigated. The information regarding Sikkim is important for two reasons. This country, which extends, between long. 88° and 89° E., from the Bengal plain to the tableland of Tibet, is the only fully explored portion of the eastern Himalaya. Our knowledge of the more extensive territories of Nepal to the west, and of Bhutan to the east, is relatively scanty.

The pioneer explorer of this interesting land was Sir Joseph Hooker seventy years ago. Since 1848–49 many others have studied its fauna and flora, its geology and topography, its scenery and people. Explorers, surveyors, collectors, members of political missions, and expert mountaineers have found in Hooker's "Himalayan Journals," published in 1852, a pleasant companion and a

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[1] "Stellar Parallaxes derived from Photographs made with the 40-in. Refractor." Publications of the Yerkes Observatory, vol. iv., part i.